Bonneville Power Administration
Fish and Wildlife Program FY99 Proposal

Section 1. General administrative information

Research/Evaluate Restoration Of NE Ore Streams And Develop Mgmt Guidelines

Bonneville project number, if an ongoing project 9016

Business name of agency, institution or organization requesting funding
Oregon State University and the University of Oregon

Business acronym (if appropriate) OSU / U of O

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NPPC Program Measure Number(s) which this project addresses.
Measure 205- Coordinated Implementation monitoring and evaluation

NMFS Biological Opinion Number(s) which this project addresses.

Other planning document references.
We have worked closley with personnel of the Wallowa-Whitman, Umatilla, and Malheur National Forests and USFS-PNW Research station for > 10 years. Much of the work will be conducted on public lands under their managment. We have received a commitment from the WWNF (Paul Boehne) for assistance in project implemetation. In additon, we have contacted private landowners, other federal agencies, and tribal specialists concerning this proposal. All have given a positive response. As this is a research proejct, our actions on the ground are expected to have minimal influences or negative impacts on the resource.

Subbasin.
Grande Ronde River, John Day River, Umatilla River

Short description.
Research and evaluate the hydrogeomorphic and ecological responses/processes of riparian/aquatic restoration and fish habitat enhancement projects in NE Oregon and develop sound habitat management guidelines and approaches based on scientific research.

Section 2. Key words

Mark	Programmatic Categories	Mark	Activities	Mark	Project Types
X	Anadromous fish		Construction	+	Watershed
+	Resident fish		O & M		Biodiversity/genetics
+	Wildlife		Production		Population dynamics
	Oceans/estuaries	X	Research	X	Ecosystems
	Climate	+	Monitoring/eval.		Flow/survival
+	Other	+	Resource mgmt		Fish disease
			Planning/admin.		Supplementation
			Enforcement	+	Wildlife habitat en-hancement/restoration
			Acquisitions		

Other keywords.
Fish habitat enhancement/restoration, Ecological interactions, hydrological interactions, geomorphic interactions

Section 3. Relationships to other Bonneville projects

Project #	Project title/description	Nature of relationship
5519100	Evaluate Meadow Creek Instream Structure and Riparian Restoration	This project represents a continuation of the research progress gained in

		this study towards our understanding of appropriate restoration approaches

Section 4. Objectives, tasks and schedules

Objectives and tasks

Obj 1,2,3	Objective	Task a,b,c	Task
1	Characterize and quantify the biotic, geomorphic, and hydrologic processes and structural features of functionally intact reference reaches. These reaches could then serve as potential goals (or endpoints) for restoration/enhancement activities.	a	Identify and establish permanent transects and sampling stations at intact stream reaches to serve as regional reference reaches
1		b	Measurements to describe the structure,function, and inherent hydrological, geomorphic and ecological processes of intact streams.
2	Quantify the geomorphic, hydrologic, and biotic responses, and the rates and mechanisms of ecosystem change at sites undergoing: (a) passive restoration alone; and (b) sites with a combination of passive and active restoration approaches.	a	Evaluate projects as to their effectiveness in terms of restoring important fish habitat features and those components of the riparian ecosystem that sustain fish habitat.
2		b	Evaluate projects as to their effectiveness relative to their stream channel configurations, such as those developed by Rosgen (1994)
2		c	At restoration/ehancement sites, measure the changes in riparian

			vegetation that have important influences on fish habitat (cover, composistion, strucutre, nutrient inputs, water quality etc.,.
		d	Measure geomorphologic and hydrologic processes and features important to fish: pools, depths, channel width, channel diversity, sediment retention, etc.,
		e	Measure changes in the aquatic biota: fish and invertebrate assemblages
3	Develop management recommendations based upon these research results which can be used to predict which type of restoration approaches will yield the highest probability to successfully restore aquatic habitats.	a	Analysis of all collected data to determine under which geomorphic, hydrologic, ecologic, and land ownership scenarios are various retoration approaches likely to have the highest probability of success.

Objective schedules and costs

Objective #	Start Date mm/yyyy	End Date mm/yyyy	Cost %
1	10/1998	9/1999	20.00%
2	10/1998	9/1999	70.00%
3	6/1999	9/1999	10.00%
			TOTAL 100.00%

Schedule constraints.
There are no foreseeable constraints

Completion date.
2003

Section 5. Budget

FY99 budget by line item

Item	Note	FY99
Personnel	Includes principle investigators, research	$125,720

	assistant, 5 grad students/yr, summer field crews	
Fringe benefits	varies depending upon posisition	$23,304
Supplies, materials, non-expendable property	field equipment, office supplies, phone charges, lab costs, etc.,	$11,850
Operations & maintenance		
Capital acquisitions or improvements (e.g. land, buildings, major equip.)	Total station surveying instrument and accessories	$10,000
PIT tags	# of tags:	
Travel	field work, per diem and travel to professional meetings	$16,490
Indirect costs	43% of the above costs	$72823.34
Subcontracts		
Other	graduate tuition	$27387
TOTAL		$287,574

Outyear costs

Outyear costs	**FY2000**	**FY01**	**FY02**	**FY03**
Total budget	$302,710	$318,642	$335,413	$353,066
O&M as % of total	0.00%	0.00%	0.00%	0.00%

Section 6. Abstract

While large expenditures have been spent on the recovery of native salmonids and their habitats in the interior Columbia Basin, a paucity of information exists on the site potential of riparian/stream ecosystems (i.e., the actual endpoint of the restoration). In addition, we know little of the biophysical processes and patterns of recovery following the implementation of passive and active restoration. The specific outcome of this research study will be to provide fish and restoration managers with the information necessary to implement the most appropriate restoration approaches in the most appropriate reach types that will re-establish the biophysical processes necessary to create productive fish habitats. The overall objectives of this research will be met through two experiments: (1) quantify the biotic, hydrologic and geomorphic characteristics of intact ecosystems; and (2) quantify the rates and patterns of recovery following the implementation of restoration activities. Specifically, we will quantify the rate and nature of hydrological, geomorphic, and ecological processes following passive restoration alone, and in combination with active restoration approaches. Both experiments will be conducted in a variety of stream reach types (gradient, elevation, stream order, floodplain width etc.,). A suite of restoration techniques will be examined (e.g., fencing, rechannelization, channel reconfiguration, instream structures, etc.,). We will quantify changes for the first five years following the implementation of restoration. Ecosystem

changes will be compared with paired untreated (control) reaches as well as with the intact reference reaches. This research will entail intensive field measurements of channel, stream, aquatic and vegetation characteristics annually.

Section 7. Project description

a. Technical and/or scientific background.

Over $200 million has been spent on stream habitat improvement projects in the Columbia Basin. Although many restoration projects using a variety of different techniques have been constructed, almost no monitoring or evaluation of different restoration techniques has been done. The overall goal of this research project is to provide scientific evaluation of specific restoration approaches and recommendations for efficient use of resources in future restoration projects.

Recent critiques of stream restoration work have pointed to: 1) a lack of clear goals or objectives; 2) well-intentioned restoration projects that have resulted in habitat degradation; 3) lack of firm and widely-understood scientific basis for restoration; and 4) lack of monitoring (Ebersole, Liss and Frissell, 1997). This research proposed will address these shortcomings. Recently developed models of channel morphology show that different stream types have different characteristic dimensions (i.e., width:depth ratio), habitat qualities (i.e., pool frequency), and rates and processes of adjustment (Rosgen, 1996; Montgomery and Buffington, 1997). Similarly, the biotic responses vary according to soils, hydrology, climate and managerial regimes (Elmore and Kauffman 1994). Thus, restoration goals should be stated in terms of optimum geomorphological, ecological and aquatic habitat standards for specific stream types and ecological communities. The research proposed here will help develop such standards by documenting geomorphological, ecological and aquatic habitat conditions achieved at pristine or functionally intact reference reaches. In addition, in this project we will quantitatively describe several restoration approaches by consistent repeated measurements. This monitoring will be used to develop recommendations for future restoration projects.

All four investigators on this project have extensive experience in researching and evaluating stream restoration efforts. They have a long history of interdisciplinary cooperation with each other including a NSF/EPA funded study in the John Day Basin to examine the geomorphic, hydrologic, and riparian connectivity to salmonids and their habitats. Beschta and Kauffman’s evaluations of restoration projects have recommended a shift away from “hard” restoration techniques and use of non-native materials in restoration (Beschta, Platts and Kauffman, 1992; Kauffman Beschta and Platts 1993; Kauffman et al. 1997). Kauffman’s research has focused on the basic ecology of riparian zones, influences of land use activities on riparian/floodplains functions, and ecological approaches to restoration. Beschta has conducted hydrological research throughout the Pacific Northwest including numerous experiments in northeast Oregon. These experiments have focused on stream temperature, channel morphology, ground water dynamics, and approaches to restoration. McDowell has conducted intensive field studies of geomorphological adjustment of stream channels in grazing exclosures in eastern Oregon . McDowell is currently conducting a project with the Umatilla National Forest to evaluate effects of in-stream structures on channel morphology and effects of a large flood in 1996 on in-stream structures. Li has researched the ecology of native and exotic fishes of northeastern Oregon including responses to land use and restoration.

These previous research efforts have resulted in several key findings that underlie the research design proposed here. 1) Restoration of riparian/aquatic systems is most successful when it results in the facilitation of natural recovery processes; 2) Some characteristics (i.e., % vegetation cover, pool area) respond within a few years while other characteristics may take several decades to change (Case and Kauffman 1997, McDowell and Magilligan, 1997a, McDowell and Magilligan, 1997b). 3) Although streams respond to management changes, response is clearly limited by the morphological range of each natural stream type (McDowell and Magilligan, 1997b). 4) Fish assemblages reflect the ecological state of the linkages between the floodplain and stream in that the riparian zones are the source of energy, nutrients, physical, and thermal environments upon which they depend (Li et al. 1994; Tait et al. 1994).

References cited in this section and examples of recent publications of the investigators can be found in Sections 7g and 9.

b. Proposal objectives. Specific, measurable objectives or outcomes for the project should be presented concisely in a numbered list. Research proposals must concisely state the hypotheses and assumptions necessary to test these. Non-scientific projects must also state their objectives. Clearly identify any products (reports, structures, etc.) that would result from this project. For example, an artificial production program may state the species composition and numbers to be produced, their expected survival rates, and projected benefits to the FWP. A land acquisition proposal may state the conservation objectives and value of the property, the expected benefits to the FWP, and a measurable goal in terms of production. Methods and tasks (in heading e, below are to linked to these objectives and outcomes (by number).

Objectives

1. Characterize and quantify the biotic, geomorphic, and hydrologic processes and structural features of intact reference reaches. These sites would serve as potential goals (or endpoints) for restoration/enhancement activities.

2. At riparian/stream ecosystem restoration project sites in northeastern Oregon, establish long term studies to quantify the geomorphic, hydrologic, and biotic responses associated with restoration/management activities. This includes quantification of rates and mechanisms of ecosystem response (structure and processes) at:
   (a) Sites undergoing passive restoration and;
   (b) Sites undergoing a combination of passive and active restoration activities.

3. Develop management recommendations based upon these research results which can be used to predict which type of restoration approaches will yield the highest probability of successful restoration of aquatic habitats.

Hypotheses

1. The rate and magnitude of recovery of riparian/stream ecosystems is influenced by the approach to restoration, the inherent physical (geomorphic/hydrologic) and biotic characteristics of the ecosystem, and the degree of anthropogenic degradation.

2. Initial changes in vegetation structure precipitate geomorphologic and hydrologic responses that assist in the recovery of fish habitats. This includes such changes as sediment retention in the active channel (new bank and point bar formation), increased hydraulic roughness, increased shade over the stream, increased allocthonous inputs, and increased interactions with the water column influencing quality.

3. Passive restoration (i.e., the cessation of those activities that are causing degradation or preventing recovery) is the most efficient and necessary first step in the restoration of riparian/aquatic ecosystems influenced by land uses occurring predominantly out of the channel (i.e., logging, livestock grazing, agriculture, roads). Because of critical interactions of vegetation with hydrology and geomorphic processes, the initial recovery of riparian vegetation is a leading edge process necessary for the recovery of aquatic habitats.

4. The probability of success in projects that include active restoration (i.e., defined as the purposeful reconstruction of hydrologic, physical, geomorphic conditions and the biotic composition) is greatly influenced by prior and current land use management. The combination of active and passive restoration approaches will greatly accelerate recovery rates of fish and riparian complexity in the majority of stream ecosystem types.

5. Those restoration approaches that re-establish habitat-forming biophysical processes or that reconnect linkages between the aquatic ecosystem and their floodplain such as they exist in functionally intact (pristine) streams will result in greater recovery of aquatic (fish) components than those that attempt to merely re-create form without function.

c. Rationale and significance to Regional Programs.

The Pacific Northwest Electric Power Planning and Conservation Act of 1980 indicated "The council shall properly develop and adopt...a program to protect, mitigate, and enhance fish and wildlife, including related spawning grounds and habitat on the Columbia River and its tributaries." As a result, the Bonneville Power Administration (BPA) has spent millions of dollars on various instream projects throughout the Columbia Basin with the goal of increasing system-wide production of anadromous fisheries through a combination of habitat restoration and enhancement measures.

For over a decade, numerous BPA-funded projects have been initiated in the upper Columbia River Basin for the express intent of improving the aquatic habitats of anadromous salmonids. Largely missing from most of these projects has been any rigorous evaluation of project success or failure. Some field reviews of some habitat projects have been undertaken (e.g., Beschta et al. 1991, Kauffman et al. 1993) and provide an overview of major problems and opportunities associated with selected projects. Recent publications (e.g., NRC 1992, NRC 1996, Beschta 1997, and Kauffman et al. 1997) have identified and summarized important concepts associated with the restoration and improvement of aquatic ecosystems. While such conceptual approaches provide an important structure for those undertaking restoration efforts, there remains a paucity of quantitative monitoring in the upper Columbia Basin on the hydrologic, geomorphic, and biologic effects of various restoration projects that would provide: 1) a better understanding of project effects upon aquatic habitats and associated riparian functions, 2) a means of determining rates of aquatic habitat improvement, and 3) a basis for projecting future trends of habitat recovery.

The proposed research is intended to provide an improved understanding of both the effects and effectiveness of existing and proposed habitat enhancement projects in the upper Columbia River Basin. One component of the project will focus on systematically characterizing the hydrologic, geomorphic, and biotic functions and processes of relatively intact riparian/aquatic systems in northeastern Oregon (Figure 2). Characteristics of these "reference reaches" will not only provide improved insights for examining the extent that human activities have altered the processes and functions of other stream reaches, but will also serve as important benchmarks for establishing restoration goals in degraded reaches.

Another component of this project will address the initial rate of hydrologic, geomorphic, and biotic change associated with recently implemented enhancement/restoration projects. Such information represents an important element in understanding how these systems function and is almost entirely lacking for habitat projects in the upper Columbia Basin. Similarly, quantitative assessments of previously implemented projects will be undertaken in this study to provide important insights into rates of change for a variety of riparian, channel, and habitat features.

It is expected that the proposed studies will provide an important scientific basis, currently lacking, for understanding the ecological principles of restoration/enhancement of sustainable aquatic habitats for salmonids. Thus, the results of this work are likely to have important ramifications for habitat improvement projects within and beyond the general geographic region of northeastern Oregon.

If sustainable and productive salmonid habitats are to be restored throughout the upper Columbia River Basin, additional efforts are needed to track the degree to which success, or failure, has been achieved and the degree to which restoration is attainable. Without such information, the substantial financial investments of the BPA (as well as Forest Service, BLM, and state agencies) for ecologically improving instream habitats will remain an unanswered question in the eyes of the scientific community, program administrators, and the public at large.

d. Project history

e. Methods.

Experimental Layout and Study Areas

There are two strongly interrelated components of this proposal. The first component will entail the quantitative description of the most intact reference reaches available in Northeast Oregon (i.e., tributaries of the Grande Ronde, John Day and Umatilla Rivers). This entails an extremely detailed characterization of the hydrologic, geomorphic, and biotic (both plant communities and instream biota) features of functionally intact reaches. It will provide the best description to date on those sites where we should "protect the best". In addition, these results could provide the blueprint for enhancement activities in that the structure and function of these areas represent successful endpoints or targets of restoration. The intact reference reaches will be established in as wide a variety of riverine systems and landscapes as possible (Table 1). Descriptions to be made in these reaches include intensive quantification of the channel morphology, water quality, riparian vegetation, soil structure and nutrient pools, and the aquatic fish and invertebrate assemblages.

The second component of this proposal entails a description of the biotic and physical changes that occur in disturbed reaches (from human causes) following the implementation of restoration activities. This includes comparisons with adjacent untreated reaches as well as the appropriate reference reaches. Measurements will be made on an annual basis starting at the initiation of restoration activities and continuing for at least 4 years. In the long term, these sites could serve as valuable reference reaches to monitor and evaluate changes into the future.

We will sample two restoration approaches in northeast Oregon. The first entails the response to simple passive restoration (i.e., the cessation of those land use activities that are causing degradation or preventing recovery (Kauffman et al. 1997). This includes activities such as riparian buffers, big game exclosures, corridor fencing, and rest from livestock grazing. However, it also includes the alterations of livestock management such that the ecosystem is recovering in a positive direction. These changes in land use management are recommended to meet TMDL standards as well as restore habitats for anadromous and resident fish populations (Clary and Webster 1989). This study will quantify the effectiveness in meeting water quality and habitat restoration goals. At least three sites will be established for permanent sampling. Each experimental site will include a treated reach, and an adjacent untreated control reach.

The second suite of restoration approaches to be examined includes the implementation of active restoration. This is defined as the purposeful reconstruction of hydrologic, physical, or geomorphic conditions; chemical clean up or adjustment of the environment; and biological manipulations including revegetation and the reintroduction of absent or nonviable native species following the implementation of passive restoration (Kauffman et al. 1997, NRC 1992). We will begin our research at the time of implementation of the channel manipulations and take measurements for a minimum of four additional years. Possible active manipulations to be examined include the placement of large wood debris into streams (whole pieces or as weirs, downstream V's etc.,), rechannelization, and channel reconfiguration. At each site, we will compare the treated reach with an adjacent untreated reach. Through time, comparisons of the restoration activities with appropriate reference reaches will be made to gage the direction and magnitude of change.

The primary level of observation and statistical comparison for channel characteristics, vegetation response characteristics, and aquatic population and habitat characteristics will be the reach. We will calculate reach-average values and variances for each characteristic, and compare these values to reach-average values for reference reaches and other standards. For some characteristics, we will also analyze and compare individual transects or cross-sections.

All data collection will be structured in terms of measuring "controlling characteristics" and "response characteristics". **Controlling characteristics** are biotic, hydrologic and geomorphic characteristics that define the system and that control potential processes and rates of recovery. We will stratify sites so that comparisons of channel adjustment are made among sites with similar morphology and adjustment processes. Sites will be stratified using basic stream characteristics such as drainage area, channel slope, bed material type, and channel type (Rosgen, 1994, 1996; Montgomery and Buffington 1996; Bisson and Montgomery 1996). **Response characteristics** are those characteristics that reflect system status (ecological health) and degree of recovery. We will quantify the rates and processes of recovery following the implementation of restoration activities by measuring two types of response characteristics:

- **Leading-edge characteristics**: characteristics "that can be used to forecast or quantify the risk of future degradation [or future improvement] in a stream" (Poole et al. 1997). Leading-edge variables are the first indicators of recovery and are characteristics that can adjust relatively rapidly. Leading edge variables include sediment retention, streambank vegetation growth, floodplain infiltration rates, bar aggradation, etc.

- **Keystone characteristics**: the most ecologically significant characteristics or features of the ecosystem. These are biotic, physical, and climatic features that are most significant in terms of supporting sensitive species, biodiversity, ecological functions, and other aspects of "ecological health". Keystone characteristics may have fast or slow adjustment rates. Keystone characteristics include streambank vegetation, large wood, salmonids, channel diversity, pool characteristics, water temperature, flood regime, etc.,

In time-trend monitoring, it is imperative that the monitoring methods be quantitative, repeatable, transferable to different field personnel through unambiguous protocols, adequately precise to detect change, and should produce data suitable for statistical analysis (Poole et al.1997). We will use rigorous sampling strategies and will establish monumented measuring points where repeated measurements are to occur over time.

Actual projects to be examined will be selected in cooperation with tribal and federal land managers as well as local watershed councils and private land owners. This cooperation will facilitate the selection of sites where scientifically valid comparisons of treated and untreated reaches can be made in "real world" situations. Quantification of changes in structure and processes in these reaches include channel morphology, sediment and nutrient retention, water quality, riparian vegetation, soil structure, nutrient pools, and the aquatic fish and invertebrate assemblages. Precise measurements are described in Table 2.

At each of the experimental restoration reaches, low level aerial photographs will be taken at the time of implementation. This will allow for the calculation of both floodplain and channel measurements at the start of the study. These detailed measures would include vegetation maps, channel sinuosity, channel width, floodplain area, and over channel cover. Locations of all measurements and permanent photo and sample points will be marked. Aerial photos will be again be obtained 5 years after implementation to quantify changes in the channel and floodplain. Copies of these photos and locations of important sampling features will be made available to the land managing entity as well as the BPA.

Table 1. Potential reference reaches for study of Northeast Oregon. Consultation with land managers, watershed councils and landowners of the region will be used to assist identification and selection of reference reaches.

Stream type	Potential reference reach
Low order Forested headwater-Rosgen Type B Channels	Upper Grande Ronde tributaries samples by Case (1995) and others
Low-order unconstrained meadow reaches Rosgen type C and E channels will be separated	W. Fk. Chicken Ck, Friday Meadows, Squaw Ck. (Grande Ronde), Upper tributaries of NFJD, reaches sampled by Magilligan and McDowell (1997) and others
Mid–order forested reaches-mostly B channels	N. Fk. Umatilla, N. Fk. Catherine Ck. and others
Mid-Order unconstrained reaches- mostly type C channels	Confluence of McCoy Ck and Meadow Ck (Tipperman Ranch) and others.
High order unconstrained and constrained reaches- mostly type C channels	North Fk John Day R., Wenaha R.

Table 2. Dependent response variables that will be measured at all reaches to be sampled in Northeastern Oregon Experimental stream sites. This includes restored reaches, adjacent untreated controls, and intact reference reaches.

Hydrogeomorphic	Vegetation/floodplain	Aquatic/water column
X-sections for width:depth ratio, entrenchment ratio	Abundance, biomass and composition within the active channel/bank full	Fish assemblages
Active Channel width/Bank full	Abundance, biomass, composition and structure in the floodplain	Invertebrate assemblages
% and area measurements of pools, riffles, glides, etc	Stream bank vegetation cover	Microhabitat Diversity
Pool frequency	Root biomass of stream banks	Redd counts
Streambank stability	Vegetation cover over channel	Water temperature
Pool length	Large wood debris	DOC, pH, Total N, P and NO_3
Pool depth	Soil organic matter	
Thalweg profiles	Soil bulk density	
Channel & floodplain roughness	Infiltration rates of floodplain	
Point bar/sediment accumulation	allocthonous inputs into the stream	
Streamflow		

Riparian vegetation and floodplain measurements

Riparian vegetation is a keystone ecosystem feature that has a strong influence on the quality of fish habitat. In this sense, fisheries enhancement and riparian vegetation recovery are one in the same. We hypothesize initial changes in vegetation structure precipitate changes in geomorphology and hydrology that lead to the recovery of fish habitats. This includes such changes as sediment retention in the active channel (new bank and point bar formation), increased channel roughness, increases shade over the stream, increased allocthonous inputs, and increased interactions with the water column influencing quality. This hypothesis will be addressed through measurement in changes in the composition, structure and mass of the riparian vegetation at all experimental reaches. Vegetation structure will be measured within the active channel (bank full) area, with in low flow area and within the entire riparian zone.

At the floodplain level the vegetation composition of the entire floodplain will be mapped utilizing low-level aerial photos and extensive ground-truthing. Each vegetation stand will be identified and classified based upon the dominant species in each vegetation layer (i.e., tree, shrub and herb layers). Within each of the dominant plant community types, changes in plant composition will be quantified through permanent transects where species frequency and mass will be measured. Ecosystem mass will be quantified as the sum of each stand area multiplied by the average mass of its community type. All vegetation measurements will follow that of Case (1995) for mass and Kauffman et al. (1983, 1985) for composition and diversity. Changes in soil properties through time (bulk density, porosity infiltration rates, and soil organic matter) will be measured. Methods follow that of Brady (1974).

To test the hypotheses of restoration, measurements of the change in vegetation composition will strongly focus on those changes that occur in the active channel areas. This is where we predict that the greatest and most immediate interactions between vegetation, hydrology, geomorphology and the aquatic biota occur. This includes the area of below bankfull (active channel) and within the base flow channel. The active channel will be delineated at each reach through measurement of wetted cross-sectional area during peak flow each year. Measurements of the area occupied during peak flow will be made in conjunction with other hydrological and geomorphological measurements made at this time. Total vegetation biomass within the active channel will be measured annually at the end of the growing season (but prior to peak flow and snowfall). This has been found to accurately quantify the quantity of vegetation biomass that interacts with peak flows during the early spring/winter months

Herbaceous vegetation biomass will be quantified through destructive sampling of ≥ 30 25 X 25 cm microplots following the methods outlined in Kauffman et al. 1984. Changes in shrub wood vegetation structure will follow that of Case (1995) and Case and Kauffman (1997). Density and structure of woody vegetation will be quantified through annual measurement of shrub density in permanently marked 2 X 25-m plots. Within each plot shrub density (by species) and structural features (crown area, stem density, diameter and height) will be measured. These are parameters necessary to quantify the vegetation contribution to channel roughness. The abundance and composition of dead and downed wood will follow that of Case (1995). All wood pieces (natural and placed will be measured and mapped in each reach annually. Streambank root biomass which has multiple functional roles in soil retention, nutrient cycles, and aquatic structure will be quantified at each site annually through quantification of mass contained in cores to a depth of 40cm following the methods of Kauffman et al. (1998). At least 10 cores per site will be excavated to quantify root biomass. The entire soil root core will be transported to the lab where roots will be extracted via an automated root washer. Annual changes in ecosystem parameters will be tested using a variety of uni- and multivariate statistical methods. Statistical tests will be preformed comparing the changes between the treated areas and the adjacent controls and where possible between areas treated with passive vs. active restoration approaches. Also, comparisons will be made between the restoration reaches and the intact reference reaches.

Hydrological/Geomorphologic Methods

While hydrologic disturbance regimes undoubtedly play an important role in the ultimate character of various stream reaches, the relatively short time frame of this project precludes long-term monitoring of hydrologic processes. Thus, detailed information will be collected at each of the selected stream reaches to characterize the hydrogeomorphic status of the reach.

Initially, each reach will be spatially referenced with a GPS system; furthermore each end of a selected reach will be monumented in the field. The length of reach utilized for intensive measurements will vary (larger streams having longer reach lengths) but will always be at least 100 m in length. In general, sample reaches will be at least 40 to 50 active channel widths (ACWs) in length. Stream discharge will be determined at each sample reach for the date of channel morphology measurements. Staff gages will be installed to allow tracking of summertime stages and flows; crest gages will also be installed at each site to establish the upper levels of flow during the period of study.

We aim to measure channel morphology in ways that capture both cross-section dimensions and downstream patterns of bed morphology We will measure channel dimensions (width, depth) using a regular sampling strategy downstream through the study reach, with measurements taken at intervals of 0.5 bankfull width or less. We will establish monumented cross-sections with permanent survey markers, for repeat survey (Harrelson et al. 1994). We will describe and measure channel bed morphology and channel unit assemblages, modifying standard procedures (USFS 1996; Moore et al. 1997; Bisson and Montgomery, 1996; Platts et al., 1987) so that results are repeatable and transferable. Channel unit dimensions will be directly measured rather than estimated. Additionally, we will define unit boundaries using explicit criteria based on bed inflection points rather than transient water surface characteristics or inferred hydraulic characteristics. Size and quality of bed material will be measured using the Wolman pebble count method including counting of fines.

Many channels become over-enlarged through bank destabilization, widening and/or incision. The result is loss of channel-floodplain interaction because overbank flooding becomes very rare. We will evaluate channel over-enlargement and loss of channel floodplain connection through the entrenchment index (Rosgen, 1996) and by quantitative comparison of channel capacity to estimated annual peak discharge (Thorne et al.1996).

In addition, more detailed measurements of channel morphology will be conducted along each reach to provide important insights into the "structure" of pools and riffles and cross-section changes over time. At locations spaced approximately 1/4 to 1/3 of the ACW along the channel, at least 100, and generally more, detailed channel measurements will be obtained at each site. These measurements will include thalweg depth, wetted width, active channel width, and proportion of each bank that is actively eroding. In addition, the elevation of near-channel geomorphic surfaces (i.e., floodplains, and terraces) will be obtained for each 5th measurement point along the channel. Riparian vegetation will be described for the near-channel margins (see methodology for riparian vegetation).

Detailed morphology measurements uniformly spaced along the channel are necessary to help assess not only the current status of a channel, but also for documenting any physical changes in channel morphology that occur naturally or as a result of enhancement projects. From these measurements, changes in mean characteristics (e.g., mean depths, mean pool/riffle ratios, mean width:depth ratios) and variances will be determined. In addition, because of the high spatial density of measurements at a uniform spacing along a reach, time-series analytical techniques will be used to characterize the spatial "structure" of channel dimensions (e.g., depths, and widths). Autocorrelation techniques will be used to help distinguish changes in pool/riffle features over time. Width:depth ratios and the frequency and morphology of pools will be of particular interest in these analyses.

Many of the stream reaches in northeastern Oregon have experienced the effects of grazing from domestic and wild ungulates. Where enhancement projects have removed grazing pressure and riparian vegetation is expected to recover, measurements of channel "roughness" will be undertaken. These measurements will occur over a range of flows that occur within the active channel (i.e., generally below bankfull). Channel roughness (Manning's n) will be calculated from detailed cross-section measurements and discharge measurements for specific flow levels at the beginning of an enhancement project. These measurements will be repeated after several years of vegetation recovery to establish the extent of change in this important hydraulic parameter. Channel roughness measurements will also be undertaken for sites chosen as reference reaches.

Aquatic Biotic Assemblages

We will use reaches 40 channel widths in length to sample aquatic fauna within the study sites. This has been determined to be of a sufficient length to capture the representative habitats at the scale of stream reach and therefore to assess the species composition of streams (Lou Reynolds and Stan Gregory, personal communication; Lyons 1992). We will follow the Suggestion of Austen et al. (1994) to characterize the fauna as comprising several guilds. They suggest that guilds detect environmental change more precisely because guilds exhibit the Acharacteristics of a super-species≅. Therefore guild membership in different habitats provides superior information concerning that habitat.

For instance, highly sensitive, resident fishes such as bull trout, west slope cutthroat trout or exotic brook trout can be used as surrogates for anadromous salmonids where underseeded drainages are impacted by migration barriers. Fish assemblages will be categorized into different temperature and habitat guilds according to the classification of Hokanson (1977) and Herbold and Moyle (1987). These will comprise the following categories coldwater midwater assemblage (bull trout, inland rainbow trout, spring chinook salmon), warmwater midwater assemblage (redside shiner, northern squawfish), coolwater benthic assemblage (mountain whitefish, torrent sculpin, Piute sculpin, longnose dace, mountain sucker, lamprey ammocoetes) and warmwater benthic assemblage (chiselmouth, speckled dace, bridgelip sucker, largescale sucker).

We will use Merritt and Cummins (1984) functional groups for classifying invertebrates, (i.e., shredders, borers, grazers, filterers, and collectors); aspects that reflect the status and composition of nearby riparian vegetation. Species composition data will be gathered according to the methods of Li et al. (1994). Species in pools will be estimated by snorkeling censuses; whereas riffles will be estimated by electroshocking. Calibration of both gears to a common method, mark and recapture estimates, will be conducted. Invertebrates will be sampled in riffles using a Hess sampler according to the procedures of Tait et al. (1994). Sample sites will be go-referenced with G.P.S.

We will determine species richness of each assemblage type within habitat units of each stream reach sampled. We will follow the methods of Li and Li (1996) for analyzing fish community composition and Tait et al. (1994) for characterizing the invertebrate communities. We will use Margalef=s Index to analyze species richness patterns within communities:

$$D_{mg} = (S-1)/\ln n$$

where S = total number of taxa in the sample, and ln is the natural log of the total numbers of individuals. We will use the Morasita-Horn index to examine paired differences between communities:

$$C_{MH} = [2*3\ (an_i bn_i)]/[da + db)\ aN\ *bN]$$

where aN is the number of individuals in site A; bN, the numbers in site B; an_i is the number of individuals of species I in site A; bn_i is the number of individuals of species I in site B.

Microhabitat Complexity and Diversity*:* This will be used to examine the relationship of channel structure to fish habitat quality. We will randomly select 20% of the habitats within each study reach to map. We will use the methods of Hirsch (1995) to index complexity, essentially a measurement of bathymetric development and use her typological approach to identify microhabitats. Diversity will be recorded using the Shannon-Weiner Index where proportions of microhabitat habitat area are used in the calculations. As each unit will have been biologically censused, we can correlate standing crops and species richness with indices of complexity and diversity.

Redd counts: We will conduct redd counts during the spring for steelhead/redband trout and during the fall for bull trout and spring chinook salmon. This will be done with consultation of the responsible district biologists. Correlations of infiltration rates on redd densities will be examined.

f. Facilities and equipment.

The majority of this project will be conducted in the field. The only specialized pieces of equipment that are not currently in the possession of the principal investigators are the total station-surveying equipment. However, this and all necessary supplies for field work can be easily purchased from scientific supply companies (i.e., tape measures, flow meters, nets, balances, sample containers, etc,. Laboratory work will be conducted in the habitat ecology laboratory of the Department of Fisheries and Wildlife at OSU. Access to state of the art analysis of soil plant and water samples has been confirmed at OSU.

Hydrological lab analyses will be conducted in the Forest Engineering labs at OSU. The Dept. of Geography at the U of O is an excellent facility for GIS analysis. Vehicles will be obtained from the University Motor Pools. Housing for this research will either be provided by the USFS or we will use field camps with OSU trailers.

g. References.

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Section 8. Relationships to other projects

This project represents a continuation of the riparian research that has been conducted by the principal investigators in Northeastern Oregon since 1990. Much of the previous research has been funded by the BPA (i.e., Evaluate Meadow Creek Instream structure and riparian restoration-BPA # 5519100. In addition, the investigators have conducted a number studies in Northeast Oregon Streams funded by the NSF, EPA, and the US Forest Service. These studies have focused on a variety of important issues pertaining to riparian/fish habitats. Specifically, much of the research has focused on stream temperatures, the role of livestock on vegetation, soils and channel structure, and the relationships between hydrological, geomorphologic and vegetation features with the aquatic environment. However, this research will be the first of its kind to quantify the ecosystem processes and structural changes associated with actual restoration projects with the goal of providing valuable information on the proper approaches to successful restoration.

Section 9. Key personnel

J. BOONE KAUFFMAN

Riparian/Floodplain ecologist-0.30 FTE

Associate Professor
Department of Fisheries and Wildlife
Oregon State University
Corvallis, Oregon 97331

EDUCATION

Ph.D. 1986 University of California, Berkeley. Wildland Resource Science/Forest Ecology
M.S. 1982 Oregon State University, Corvallis. Rangeland Resources
B.S. 1978 Texas Tech University, Lubbock. Range and Wildlife Science

EMPLOYMENT

6/1995-present - Associate Professor Dept. of Fisheries and Wildlife, Oregon State University. Teaching and Research: Habitat, disturbance, and ecosystem ecology of riparian ecosystems - ecosystem dynamics and influences of disturbances on biological diversity, biogeochemistry, and site productivity in tropical and temperate ecosystems.

3/1986-6/1995 - Associate Professor (1991), Assistant Professor (1986-1991), Dept. of Rangeland Resources, Oregon State University. Teaching and Research: Riparian Ecology, Fire Ecology, and Disturbance ecology.

EXPERTISE

Dr. Kauffman has been conducting research in riparian zone ecology for 20 years. Most of that research has been in Northeast Oregon. He also currently teaches the wetlands and riparian ecology course at OSU. Research has focused on the plant ecology, biogeochemistry, and floodplain/stream interactions. His research has largely been applied in nature with an emphasis on restoration ecology and how land use influences the dynamics of riparian/stream ecosystems. Dr. Kauffman has authored over 100 scientific papers.

SELECTED PUBLICATIONS

Elmore, W. and J. B. Kauffman. 1994. Riparian and watershed systems: Degradation and restoration. pp. 212-232. IN: Vavra, M., W. A. Laycock and R. D. Pieper (eds.). Ecological Implications of Livestock Herbivory in the West. Society for Range Management, Denver, CO.

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ROBERT L. BESCHTA
Professor of Forest Hydrology 0.25 FTE
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Corvallis, Oregon 97331

EDUCATION
Ph.D. 1974 University of Arizona. Watershed Management/Hydrology
M.S. 1967 Utah State University. Forest Hydrology
B.S. 1965 Colorado State University. Forest Management

EMPLOYMENT
12/1974-present - Professor (1987-present), Acting Department Head (1987), Associate Professor (1980-86), Assistant Professor (1974-80), Department of Forest Engineering, Oregon State University. Teaching: Watershed Processes and Management, Forest Land Use and Water Quality, Snow Hydrology. Research: Sediment transport in mountain streams, role of riparian vegetation on stream temperatures and channel morphology, subsurface flow in riparian areas, hydrology of wetlands, and others.

EXPERTISE
Dr. Beschta has been conducting research on forest and range watersheds in the Pacific Northwest for over 20 years. In 1982, he undertook a Sabbatical with the University of Canterbury in New Zealand. He has served as Academic Vice President for the American Institute of Hydrology, as a member of the National Research Council committee on protection and management of Pacific Northwest Anadromous Salmonids, and has participated in scientific advisory teams for the governor (e.g., forest health of eastside forests and landslides in western Oregon). Dr. Beschta has been a co-organizer of several major Pacific Northwest symposiums on riparian management, erosion, and sedimentation; he has also taught in various workshops and shortcourses (e.g., precipitation and runoff of mountainous watersheds, effects of vegetation

on the hydrology of riparian areas and channel morphology, water quality monitoring, hydrology of wetlands and riparian areas, and others. Over the last 15 years, Dr. Beschta has authored or co-authored over 70 publications related to the hydrology of forest and range watersheds. He is a Certified Professional Hydrologist (#317) of the American Institute of Hydrology.

SELECTED PUBLICATIONS

Hill, M.T., W.S. Platts, and R.L. Beschta. 1991. Ecological and geomorphological concepts for instream and out-of-channel flow requirements. Rivers 2(3):198-210.

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Degrees Earned:

Ph.D. (Geography), May 1980, University of Wisconsin, Madison, Wisconsin
M.C.R.P. (Environmental Planning), May 1977, Illinois Institute of Technology, Chicago, Illinois
B. Arch., May 1971, Illinois Institute of Technology, Chicago, Illinois

Current Employment:

Professor, Department of Geography, University of Oregon
Duties: Teaching (Geomorphology, Fluvial geomorphology) and Research

Employment History and Other Professional Activities:

Assistant Professor to Professor, Department of Geography, University of Oregon, 1982-present
Head, Department of Geography, University of Oregon, 1993-96
Associate Vice President for Research, University of Oregon, 1990-92.
Member, Board of Directors, Oregon Water Resources Research Institute, 1991-94.
Chair, Geomorphology Specialty Group, Association of American Geographers, 1990-91.
Member, State of Oregon Governor's Watershed Enhancement Board Advisory Committee, 1987-90.

Expertise: Directed a research project "Processes and Timing of Hydraulic and Geomorphic Adjustments during Stream Channel Recovery," on stream channel response to elimination of cattle grazing pressure in eastern Oregon, 1993-97, funded by NSF. Co-PI on a multidisciplinary project, "Hydrological, geomorphic and ecological connectivity in Columbia River watersheds" (funded by EPA Water and Watersheds program, 1996-99), with responsibility for analysis of geomorphic and geologic controls of stream temperatures. Conducted research funded by the Umatilla and Malheur National Forests on stream channel geomorphic conditions and processes. Extensive experience in field survey, analysis of channel unit and stream inventory data, soil and sediment analysis, GIS analysis, and aerial imagery interpretation.

Selected Research Publications:

"Stream channel adjustment following elimination of cattle grazing," F. J. Magilligan and P. F. McDowell, Journal of the American Water Resources Association (formerly Water Resources Bulletin) 33: 867-878 (1997).

"Response and recovery of stream channels following removal of cattle grazing," P. F. McDowell and F. J. Magilligan, in Wang, S.S. Y., Langendoen, E.J., and Shields, F.D., Jr., eds., Management of Landscapes Disturbed by Channel Incision: Stabilization, Rehabilitation, Restoration, p. 469-475. Oxford Mississippi: University of Mississippi, (1997).

"Long-term environmental change," P. McDowell, T. Webb III, and P. Bartlein, in The Earth as Transformed by Human Action, B. L. Turner and others, eds., p. 143-162, Cambridge University Press, (1990). Also reprinted in Ecological Time Series, T. M. Powell and J. H. Steele, eds., Chapman and Hall (1995).

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"Evidence of stream response to Holocene climatic change in a small Wisconsin watershed," Quaternary Research 19: 100-116 (1983).

CURRICULUM VITAE

HIRAM W. LI

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Professor and Assistant Leader

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EDUCATION:

A.B. - Zoology, University of California, Berkeley, 1966; **M.S. - Fishery and Wildlife Biology**, Colorado State University, 1973; **Ph.D.- Ecology,** University of California, Davis, 1973

EXPERIENCE:

Professor and Assistant Leader, Oregon Cooperative Fishery Unit, Department of Fisheries and Wildlife, Oregon State University. 1988-Present; **Associate Professor and Assistant Leader**, Oregon Cooperative Fishery Unit, Department of Fisheries and Wildlife, Oregon State University. 1979 to 1988; **Assistant Professor**, Department of Wildlife and Fisheries, University of California, Davis. July 1973 to January 1979.

PROFESSIONAL ACTIVITIES:

Ecology Advisory Panel for the National Science Foundation 1984-1987; **Associate Editor** for Transactions of the American Fisheries Society 1986-1988; **Foley-Hatfield Congressional Team** on Eastside Forest Health Assessment, 1992-1993; **Referee** for 14 primary journals

HONORS AND AWARDS:

Commendation Award, Sport Fishing Institute (1978); **Quality Performance Awards,** U.S. Fish and Wildlife Service (1982, 1989, 1990, 1991); **Director's Research Excellence Award**, U.S. Fish and Wildlife Service
(1991); **Special Achievement Award**, U.S. Fish and Wildlife Service (1992, 1993, 1994); **Outstanding Group Achievement Award, American Institute of Fishery Research Biologists** (awarded to the Cooperative Fish and Wildlife Research Units) (1992)

PUBLICATIONS: 30 refereed papers in Primary Journals, 10 Book Chapters, 30 Technical reports.

FIVE PUBLICATIONS RELATED TO THIS PROPOSAL :

Li, H.W., G.A. Lamberti, T.N. Pearsons, C.K. Tait, J.L. Li. 1994. Cumulative impact of riparian disturbance in small streams of the John Day Basin, Oregon. Transactions of the American Fisheries Society 123(4):627-640.

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Section 10. Information/technology transfer

There will be a number of refereed journal articles that arise out of this research. Papers will be published in ecological, hydrological, geomorphic, fisheries and management oriented journals. In addition, we expect that at least 6-9 graduate theses would result from this research. A number of professional presentations would be made at workshops and symposia. In addition, the investigators will deliver seminars for land managers and the interested public in Northeastern Oregon and other parts within the Pacific Northwest. The consultation and dissemination of information to land management agencies, tribes, private landowners and the interested public are a major responsibility of the University Professors involved in this research.